PITMAN'S 'SIMPLY EXPLAINED' SERIES

FLYING SIMPLY EXPLAINED

By **MALCOLM LOGAN**

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FLYING SIMPLY EXPLAINED

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THE AEROPLANE SIMPLY EXPLAINED

Explains in Simple Language the Principal Constructional Details of the Aeroplane and How and Why it Flies.

Describes the main constructional features of the aeroplane and gives a simple explanation of its working. Even the novice will find no difficulty in following the explanations, while the many diagrams ensure complete understanding.

CONTENTS: Preface—Monoplanes and Biplanes—How an Aeroplane is Controlled—The Engine Controls—Instruments—Why an Aeroplane Flies—Water Aircraft.

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PREFACE

THIS book attempts to explain as clearly as possible the general procedure of flying a light aeroplane. It is written primarily for those who have yet to fly or have not yet had the opportunity of receiving flying instruction. It is not a manual of instruction, but at the same time it is hoped that it will afford a real insight into the groundwork of flying and what it entails.

Those who are interested in the question of why an aeroplane flies and how it works will find these subjects more fully dealt with in the companion book, *The Aeroplane Simply Explained*.

To those wishing to go more deeply into the subject, I recommend the following three books: *Learning to Fly*, by Frank A. Swoffer, *Aeroplanes and Engines*, by W. O. Manning, and *The Civil Air Guard Book*, by Malcolm Logan.

FLYING SIMPLY EXPLAINED

THE MAKING OF A PILOT

WILL I make a pilot ? This question often arises in the minds of those who have not had the opportunity to fly. The answer in the majority of cases is *yes*. The handling of an aeroplane in ordinary circumstances does not call for any exceptionally high degree of skill, or for qualities which are not readily found in the average man or woman.

Perhaps the first essential is a keen desire to fly. This in itself will not make a pilot, but it has proved an outstanding characteristic in many who have made names for themselves in aviation. The early pioneers were in many cases men whose sole thought was to get into the air. Driven on by this desire, they not only learned to fly in the face of extraordinary difficulties, but in some cases designed and built their own planes and flew them.

To-day the lot of the would-be pilot is comparatively easy. He can take to a machine confident that it will not fail him, and knowing that he is in the safe hands of an experienced instructor. Generally speaking, success or failure will depend on the pupil himself.

Among other qualities needed, one might mention self-confidence, a reasonable degree of coolness, and the faculty of making one's limbs quickly obey mental impulses. Eye, brain, and muscle must work together. Riding a bicycle, driving a car, and a number of sports all call in some degree for this response between the senses and the muscles.

People sometimes ask, will a good driver make a good pilot? The answer is probably yes. Many good drivers are expert pilots, although one cannot really compare driving with flying. It is a curious fact, however, that some good pilots make very bad drivers, so perhaps the answer does not get us very far.

It must be remembered that whereas the majority of people can be taught to fly an aeroplane, some will not progress beyond the stage of being ordinary flyers. As in everything else, the expert usually possesses just that something extra that the others haven't got; in every case, however, he will be found to possess the qualities of restraint and care. Slapdash methods and over-confidence are the worst enemies that a flyer can have. Lindbergh, in spite of his spectacular achievements and many narrow escapes, is a careful pilot.

A slow learner often makes a very good flyer in the end. Von Richtofen, the great German ace, was a poor pupil, and at one time his instructors nearly gave him up.

Broadly speaking, learning to fly will consist in acquiring what is called *air sense*. This will consist in getting the *feel* of an aeroplane, in knowing what it is doing, an how to make it do the right things without pausing to think.

Flying Instruction. Flying to-day is taught on what is known as the dual control system. That is, the instructor and pupil each has a set of controls, which are so connected up that their movements are identical. The instructor can thus show the pupil how to execute any particular manœuvre.

Flying time in the air is counted in hours. Normally speaking, a pupil will not be allowed to take a machine up by himself (go solo) until he has had eight hours' instruction. Some people are actually capable of flying solo in four or five hours, while others take as many as seventeen or more hours before they can be safely trusted to take to the air alone. After the first few solo flights, more dual instruction will follow to ensure that the pupil has not developed bad habits while flying solo; he will also require the presence of an instructor during the more advanced stages.

There are a large number of flying clubs in the United Kingdom. Instruction is given at the rate of 30s. and upwards an hour. The Civil Air Guard now enables people to learn flying at rates which are as low as a half-crown an hour.

Gliding provides an excellent and cheap form of flying training. Once the art of flying these engineless machines is mastered, it is but a short step to the handling of powered aircraft. There are now some twenty gliding clubs in Britain where pupils receive instruction for as little as 3s. a day; in the future gliding is likely to play an important part in the training of all air pilots.

THE AEROPLANE

Before we can understand how an aeroplane is flown, we must know something of the aeroplane itself and also of the controls, by which means the pilot makes it obey him.

We will see first of all why an aeroplane flies. Some people imagine that the propeller keeps it in the air. So it does, in a way; but even so, we can fly long distances in machines which have no engines. An aeroplane is lifted by its wings, for these are so shaped that they react to the stream of air which flows over their surfaces when the aeroplane is in motion. If we want to find out what causes that motion, we must turn to the propeller.

The Propeller. The propeller, or as it is sometimes termed the airscrew, is driven round by the engine. We know what a boat's propeller does when it revolves in the water: it drives the boat along. An aeroplane's propeller does much the same thing in the air, and being situated in the fore part of the machine its function is to pull rather than push it along. In some cases the engine and propeller are placed behind the wings, and the action is then more like that of a boat's propeller; such types as known as *pusher* aircraft.

The Wings. Let us see briefly what happens to an aeroplane's wings when moving forward through the air. They are attached to the body or fuselage of the machine so that they meet the oncoming air at a slight angle (Fig. 1), called the *angle of incidence.* This tends to make them lift. If anyone wants to see this for himself, he has only to move a piece of paper or cardboard at a slight incline through the air (as shown in Fig. 2), and he will find that it tends to lift in the hand. A wing inclined at an angle of incidence does the same thing—the faster it is moved forward, the more lift it receives.

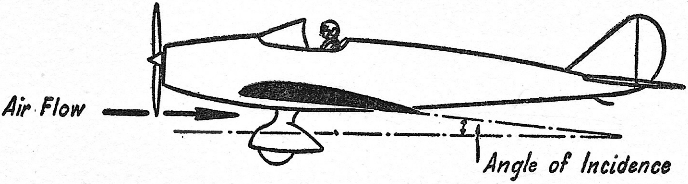

FIG. 1

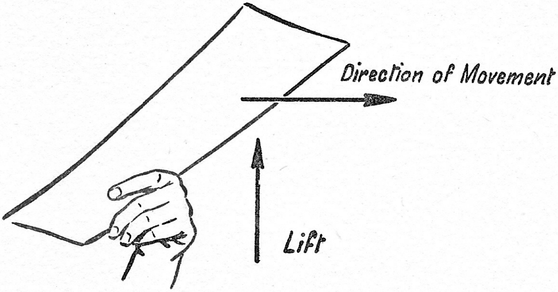

FIG. 2

Many people are not aware that the upper surface of a wing plays a very important part in lifting an aeroplane. When the air rushes over the curved upper surface, it does not entirely succeed in following the line of that surface (Fig. 3); in effect, the air flow leaves an empty space or partial vacuum over the top of the wing. This causes an upward suction which pulls the wing upwards, and nearly two-thirds of the total lift on a wing is exercised on its upper surface in this way.

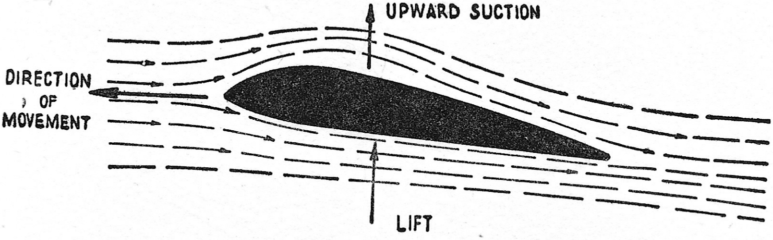

Fig. 3

The Controls. The controls of an aeroplane are situated in front of the pilot's seat, which is itself located in the cockpit. This resembles a small cabin in the forward end of the fuselage. The cockpit may be open or enclosed, and may embody side-by-side seating. In some cases there may be two cockpits one behind the other, each having its own set of controls, which are interconnected in the system as previously mentioned.

Let us look at the controls which will confront the pilot of an ordinary light aeroplane.

Rising from the floor of the cockpit in front of the seat is a vertical column or stick (Fig. 4), generally known as the control stick. It is held by the pilot when he is seated, and is capable of being moved backwards and forwards, and also from side to side. First we will see what happens when the control stick is moved backwards or forwards.

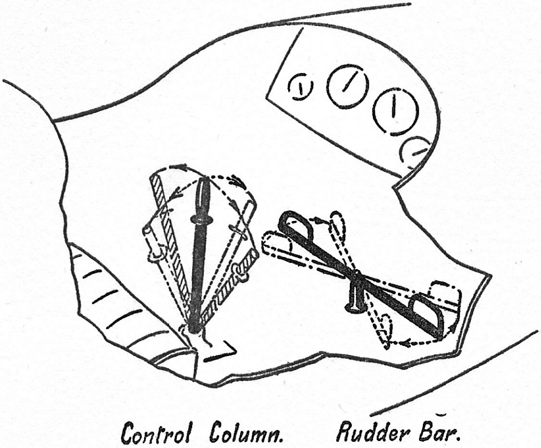

Fig. 4. Interior of Cockpit, showing Control Column and Rudder Bar and their Respective Movements

The Elevator. It will be found that this movement causes a movable surface at the tail to be raised or lowered according to whether the stick is pulled backwards or pushed forwards. This movable surface is called the elevator (Fig. 5). The tail unit as a whole comprises two sets of surfaces, one vertical and the other horizontal; the elevator forms part of the movable horizontal surfaces. The fixed part, which is called the tail plane, will be explained later.

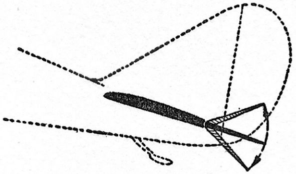

Fig. 5. Tail Unit, showing Tail Plane and Movements of Elevator

The elevator controls the machine's movements in an up and down direction when it is in level flight. Imagine that the machine is flying with the elevator (as it would in level flight) lying more or less in a line with the tail plane. If the control stick is pulled backwards, the elevator is raised, and in this position it gets in the way of the stream of wind which is rushing along the upper surface of the tail plane. The wind tries to blow the elevator out of its way; that is, down level again. This results in a downward pressure which pushes the whole tail of the machine downwards. As a result the nose is pointed upwards at a climbing angle (Fig. 6).

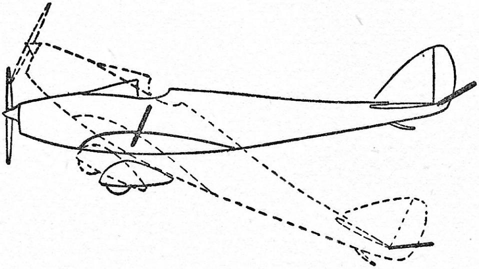

FIG. 6

Now if the pilot pushes the control stick forward, the elevator is forced *down* below the level of the tail plane. The air flow, as before, tries to blow it out of its way; that is, upwards this time. This results in an upward pressure on the tail which tilts the nose of the machine downwards at a gliding angle. Thus, if the pilot wants to climb, he pulls the stick back; if he wishes to descend, he pushes the stick forward.

The Ailerons. We noticed that the stick was also capable of sideways movement. This affects the banking movements of the machine. An aeroplane is said to be banked when it is canted over or lying on its side in the air.

The surfaces which are affected by sideways or lateral movements of the stick are situated in the rear or trailing edge of each wing. Part of this trailing edge extending some distance along the wing from the wing tip resembles a movable flap. This is called the aileron (Fig. 7), and it is capable of being raised or lowered in the same way as the elevator.

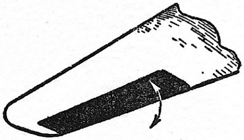

FIG. 7. THE BLACK PORTION SHOWS THE AILERONS

Arrows show direction of movement, see also Fig. 8.

How They Work. Let us see what happens when an aileron is moved into the raised position by a lateral movement of the stick. The wind does what it tried to do with the raised elevator: it tries to blow it back again —that is, downwards. The effect of this is to cause a loss of lift on the wing, so that it tends to drop.

Now, supposing the aileron were lowered so that it lay below the level of the wing surface. The wind will try to blow it back and upward, and the lift on the wing will be increased. The wing will rise.

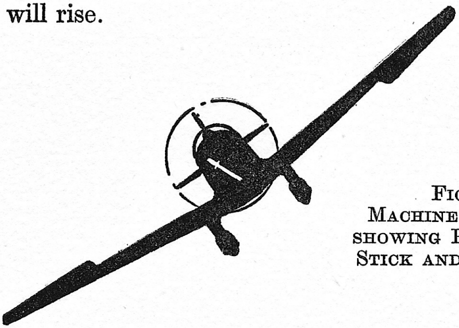

FIG. 8
MACHINE BANKED, SHOWING POSITION OF STICK AND AILERONS

If we raise one aileron and lower the other, we shall therefore have an added lift on one wing and a decrease in lift on the other. One wing will rise and the other will drop. The machine will heel over on to its side and assume a banked position (Fig. 8).

The ailerons of an aeroplane are so connected with the control stick that a sideways movement of the latter raises one aileron and lowers the other at the same time. If the stick is moved to the right, the right aileron moves upwards and the left aileron is lowered. This, as we have seen, will result in the right wing dropping and the left wing rising, in other words, a right bank. Similarly a left-hand movement of the stick will result in the machine's banking to the left.

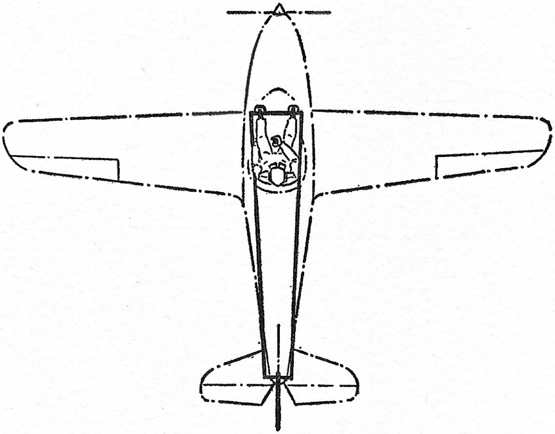

FIG. 9

The Rudder. If we look at the floor of the cockpit, we shall see a horizontal bar at the place where the pilot's feet would normally rest. The bar pivots on a central point, rather like the handlebar of a bicycle. It is operated by the pilot's feet (Figs. 4 and 9).

This control is called the rudder bar and operates the rudder. We saw that in addition to the horizontal surfaces, which were composed of the tail plane and elevator, there were also two vertical surfaces embodied in the tail unit. In common with the tail plane and elevator, one of these surfaces is fixed and one is movable. The portion which is fixed is called the fin, and more will be said about that later. The rear and movable portion is the rudder (Fig. 10). It resembles a boat's rudder and is the control surface chiefly responsible for steering the machine.

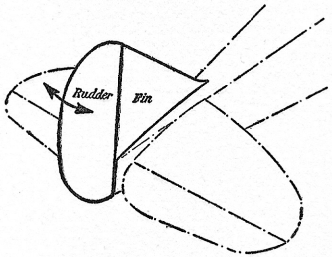

FIG. 10

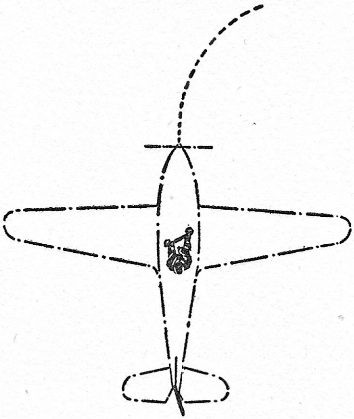

FIG. 11

Its Effect. When the pilot moves the rudder bar with his right foot, the rudder moves over to the right of the central line—this has the effect of turning the nose of the machine as though towards its right wing tip (Fig. 11). This means that, in level flight, its nose will swing to the right. Similarly, pressure of the left foot on the rudder bar will cause the machine's nose to swing to the left.

It is important to remember this effect of the rudder on the machine's movements. Many people are apt to think of the rudder bar as turning an aeroplane in the same way as a bicycle handlebar turns a bicycle. Fig. 12 will show that the effects are exactly opposite. Flying instructors receive large numbers of pupils who think of the rudder bar in terms of a bicycle handlebar and tend to misapply the rudder in consequence.

We have now covered the controls and have seen that in level flight each will affect the machine in the following ways:

1. Control stick pulled back or eased forward: The machine climbs, or descends at a gliding angle. This is called the fore and aft control.

2. Stick moved sideways: The machine banks to the right or to the left. This is the lateral control.

3. Rudder pushed by left or right foot: The machine swings to the left or right respectively. This is the rudder control.

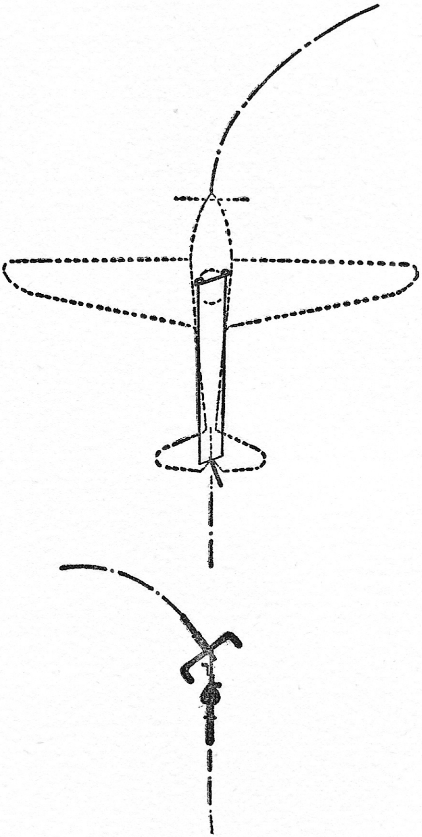

Fig. 12

STABILITY

A satisfactory aeroplane should do more than merely obey the pilot when he moves the controls. It should have balance. If a machine is made to assume a certain attitude through the movement of any control, it should come back to normal flying position soon after the pressure of the pilot's hand or foot is withdrawn from that control. If the pilot pushes the stick forward, the machine will dive; but it should come back to a level keel of its own accord when he ceases to hold the stick forward. Similarly, if the machine is thrown out of its normal flying attitude when passing through a region of disturbed air, it should return to a level keel as soon as it has left that disturbance behind it. This characteristic, which is possessed to a greater or lesser degree by all modern aircraft, is called stability.

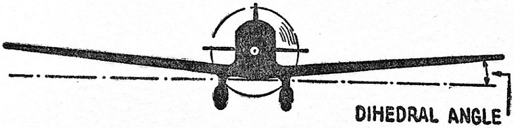

FIG. 13

How it is Obtained. We saw that there were two fixed surfaces incorporated in the tail unit, namely the tail plane and the fin. The tail plane gives the aeroplane stability in a fore and aft direction. It keeps it from pitching up and down or suddenly diving when the balance is temporarily disturbed. The fin gives directional stability: it keeps the aircraft flying straight.

We have still one other direction in which a machine must be stable, and that is laterally. If a gust of wind tilts it sideways, it should be able to regain its balance of its own accord. If an aeroplane is looked at from the front, it will be seen that the wings are tilted up at a slight angle above the horizontal. This angle is called the dihedral angle (Fig. 13).

If a gust of wind tilts the aeroplane sideways and it slips, the lower wing on account of its upward tilt is subjected to a lifting action by the oncoming air. This lifts it up again and restores the lateral balance of the machine.

THE TAIL TRIM

If an aeroplane will fly straight and level in calm air when the pilot's hands are taken off the controls, it is said to be flying trimmed. Obviously, any increase or decrease of weight at the nose of the machine will upset the fore and aft balance. A machine may carry varying weights from day to day in the shape of passengers or freight. According to how the weight varied from one flight to another, the pilot might have to pull back on the stick to hold the nose of the machine level, or push forward on the stick if the nose had been relieved of much weight and tended to rise. This state of affairs would be most unsatisfactory.

At the side of the pilot's cockpit is a lever or a wheel called the tail trim, and it is used to adjust the balance of the stick or the set of the elevator so that the aeroplane will fly trimmed under varied conditions of load.

STARTING UP

Aircraft may be fitted with various types of self-starter, but the light aeroplane is usually started by someone swinging the propeller.

The speed of an aeroplane engine is controlled by means of a throttle lever, which is situated at the side of the cockpit. The current from the magnetos is switched on or off by means of two switches. There are two because the engine has two magnetos.

When starting up, the switches are first of all turned *off* and the throttle lever is pushed half-way forward. The propeller is then turned over several times in order to fill the engine cylinders with petrol and air mixture. If someone is assisting the pilot by turning over the propeller for him, it is important that there should be a complete understanding between these two people. The mechanic or whoever is turning the propeller cannot see the position of the switches, and will rely on the pilot to tell him whether they are on or not.

Usually the words "switch off" are repeated by both men so that there shall be no chance of a misunderstanding. When the process of filling the cylinders (called sucking in) has been completed, the switches are put on. The pilot says *contact*, and this is repeated by the mechanic to show that he understands. He now grasps the propeller and gives it a sharp turn, taking care to be well clear of it as the engine bursts into life.

Many light aeroplanes are not fitted with wheel brakes, and a pair of large wooden wedges called chocks are put in front of the wheels to prevent the machine moving forward while the engine is being run up on the ground.

The engine is allowed to run for some time to warm up, and is then tested by opening up the throttle. This is accomplished by moving the throttle lever forward.

When the pilot is satisfied, he signals by waving his hand, the chocks are removed, and the machine is ready to move off.

MANŒUVRING ON THE GROUND

When an aeroplane is manœuvring on the ground under its own power, it is said to be taxying. This must be carried out very carefully, as a great deal of damage has been done in the past by inexpert or rash handling of aircraft under these circumstances.

The aeroplane should move forward at a brisk walking pace, and if the weather is rough it may be necessary for someone to walk with it, holding the wing tip that is pointing into wind.

Many types of light machines afford a poor view from the cockpit when they are on the ground, the cowling or covering of the engine often blocking any direct view ahead. While taxying, the pilot must have a clear idea of what is happening in and around the landing area. For this reason he should look out on alternate sides of the cockpit or steer a zigzag course across the aerodrome so that he can frequently view the landing field on either side of him.

As the aeroplane is only moving forward slowly, there will be an inconsiderable air flow passing over the control surfaces. For this reason the machine will not be particularly sensitive to a movement of the controls. When taxying, therefore, these movements will be much more exaggerated than they would be when the machine is in flight.

The handling of the controls will vary according to whether the machine is taxying into wind or down wind; that is, with the wind behind it.

When taxying *into wind* the stick is pulled back, and as mentioned previously, this has the effect of raising the elevator. The wind blows against it and tends to keep the tail down (Fig. 16).

When taxying down wind, the stick is held forward. This lowers the elevator and tends to prevent the following wind getting under it and possibly blowing the tail up into the air.

Supposing that we wish to turn to the left when taxying *into wind*. The throttle is opened, which gives the aircraft increased forward speed. The rudder is pressed hard over with the left foot and the stick is moved over to the right-hand side of the cockpit. This procedure is *never* adopted for turning in the air. However, on the ground it has the effect of helping the turn. The lowered aileron (that is, the one on the left wing) offers more resistance to the oncoming air than the raised one. It therefore sets up more of a drag on that wing, which helps to swing the aeroplane round in the desired direction (Fig. 14).

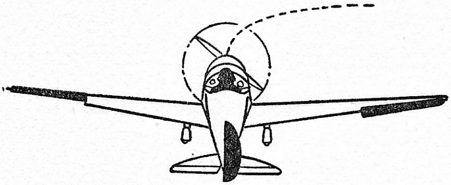

FIG. 14

When turning left with a following wind, the stick is moved to the same side as the turn, i.e. left rudder and stick over to the left-hand side of the cockpit.

FLYING STRAIGHT AND LEVEL

A pupil must first of all learn to fly a machine straight and level. The driver of a car or a boy riding a bicycle has only two possible changes of direction. He can go either to the left or to the right. Keeping straight is merely a matter of steering.

To fly straight and level, a pilot must not only watch his line of direction, but he must also maintain the machine level both fore and aft and laterally. If he flies with the nose of the machine slightly up or down or allows one wing to drop, then he has temporarily failed.

The Horizon. After a short while, the act of maintaining straight and level flight becomes almost automatic. The secret lies in watching the horizon and in light handling of the controls.

When a machine is flying level, the horizon will appear to cut the top of the engine cowling, or some other part of the aeroplane, according to its design (Fig. 15). This will be so at whatever height the aeroplane is flying. The position of the wings can be similarly gauged by reference to the horizon on each side.

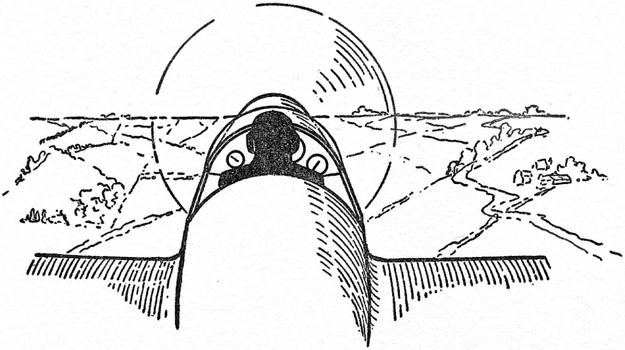

FIG. 15. LEVEL FLIGHT

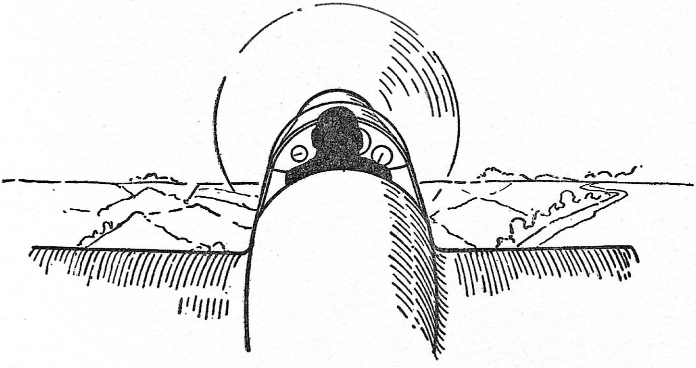

FIG. 16. CLIMBING

When the machine climbs, the horizon will disappear below the nose (Fig. 16). Similarly, when it assumes a gliding angle, the nose will appear to drop below the line of the horizon (Fig. 17). When this happens, the pilot will ease the stick gently back until the position of the horizon line tells him that the machine is again flying level.

It is important to notice that the stick should be eased rather than pushed through the necessary movements. Rough or jerky handling of the control stick will almost always result in erratic flying. The aeroplane is sensitive to very small movements of the controls when it is flying at normal cruising speed. A pupil soon finds that it will tend to fly itself in reasonably calm weather if allowed to do so. He will realize that a firm, gentle movement of the stick will when necessary restore the aircraft to a level attitude.

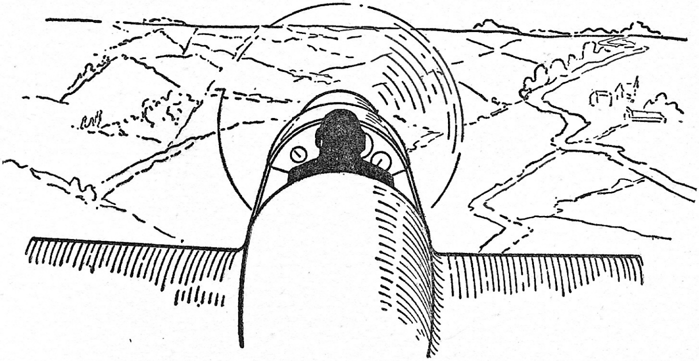

FIG. 17. GLIDING

Bumpiness. The novice on his early flights is often surprised to find that the air is not as smooth as he imagined. At times it can throw the machine about, bouncing it up and down like a cork on choppy water. On such occasions the air is referred to as being bumpy.

One sometimes hears people talking about air pockets. It is quite commonly supposed that pockets or vacuums exist in the atmosphere and that these cause the sudden losses of height to which an aircraft may be subject over certain areas and in certain weather conditions. Pockets or vacuums in the air do not exist. The conditions which have given rise to the belief are caused in the following manner.

One is accustomed to thinking of wind as a current of air flowing horizontally over the ground. However, the flow of air over the earth's surface is *not* always horizontal. There are various causes present which tend to produce vertical currents as well. These, and minor disturbances due to gusts and squalls, tend to prevent steady flying and produce the conditions known as bumpiness. If an aircraft is flying in a steady horizontal wind flow and enters a region where there is an up current, it is subjected to a sudden lift which is called a bump. Similarly, if it enters a region of descending air, it experiences a decrease in lift. This is sometimes referred to as an air pocket. Other reasons for disturbed air arise from what are called *temperature thermals*—columns of air which are warmer than the surrounding air, and thus rise. Many of us are familiar with the expression *hot air rises.* It is the exaggerated condition of these rising columns which may produce clouds and sometimes thunderstorms with violent air eddies.

A pilot frequently finds that bumps occur when flying low, especially over hilly country or the roofs of a town. This is because these obstructions in the path of the wind tend to divert it from its horizontal course and send it shooting upward (Fig. 18).

When an aeroplane is flying through a bumpy region, it is often thrown out of its level attitude. At times it may be

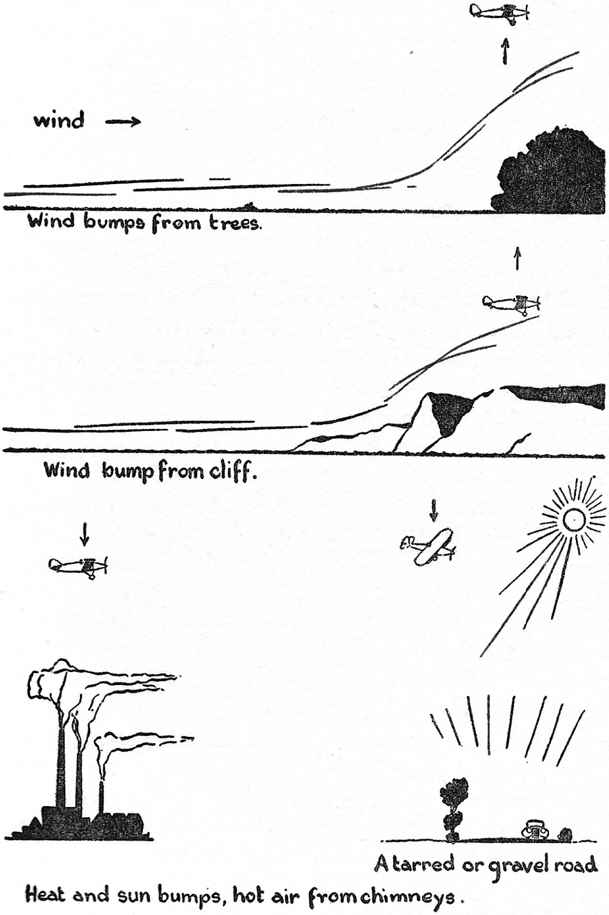
wind
Wind bumps from trees.
Wind bump from cliff.
A tarred or gravel road
Heat and sun bumps, hot air from chimneys.

FIG. 18. SHOWING SOME ADDITIONAL CAUSES OF BUMPINESS

necessary to correct these changes by a movement of the controls. In less severe cases the aeroplane will tend to right itself when the disturbance has passed. It does this because of its stability, and this characteristic we have already discussed.

STALLING

Many people who have never flown are already familiar with this term. Stalling is not in itself dangerous; in fact, it is often done on purpose and is perfectly safe, provided that it is done at a sufficient height above the ground.

We said that an aircraft derives its lift from the action of the air flow over the wing surfaces. If the rate of this air flow falls below a certain point, the lift on the wings becomes insufficient to keep the aeroplane in the air. Its controls, notably the ailerons, in theory become useless and the machine continues to fall until its downward speed is sufficient to restore an effective air flow over the lifting surfaces. Obviously, if these conditions occur near the ground, the machine crashes before it can regain the necessary speed to make it fly again, or, to use the proper term, becomes airborne.

The rate of the air flow will depend on the machine's speed relative to the air surrounding it; that is, its air speed. This is shown on an instrument dial called the *air-speed indicator*. Thus, if it is flying against a stiff wind, it may be passing quite slowly over the ground and yet have a rapid flow of air passing over its surfaces. In other words, it has a high air speed. If, on the other hand, it is flying with a fast following wind, it will have to fly much faster over the ground to achieve the necessary air speed.

Avoiding a Stall. Air sense, that peculiar sense which all good airmen develop, tells the pilot when he is in danger of stalling. The pupil will begin to recognize the signs consciously by the feel of the controls or by listening to the sound of the wind as it rushes by the machine.

When the air speed has dropped to somewhere near the stalling point, the controls are very easy to move to and fro, and their movement has little effect on the aeroplane. When the controls feel like this, they are said to have become *sloppy*. This is always an indication that an aeroplane has nearly reached its stalling speed.

When this happens, the sound of the air as it passes the plane sinks to a bare murmur. In normal flight it should rush by with a brisk swishing note and an experienced pilot would know from the sound alone whether he was near the stalling point.

A third and more obvious indication of a coming stall would be the speed figure shown on the air-speed indicator. The stalling speed is usually marked on this instrument or is prominently indicated in figures on or near the instrument board.

Pupils are not encouraged to watch this instrument as a means of gauging the safety of their speed. They should first acquire the warning sense through the feel of the controls and by ear.

Intentional Stalls. In order to acquaint a pupil with the sensations that precede a stall, an instructor will usually put the machine into an intentional one. This is not usually done much below an altitude of 2000 ft. The aeroplane is climbed to the required height and the engine is throttled down by pulling the throttle lever back to its fullest extent. This does not stop the engine, but keeps it just ticking over. If the nose is held level or raised slightly, the speed will fall away and it will become possible to make a violent sideways motion of the stick without any appreciable result. It will also be noticed that it offers little resistance. The lateral control has become sloppy, and the ailerons have lost their effect. The aeroplane seems to hang in the sky, then suddenly the nose drops and the machine falls rapidly (Fig. 19).

In order to get out of the stall, the stick is eased forward until flying speed has been regained. It is, of course, possible to stall with the engine on, and this can be accomplished by pulling the nose of the machine into a steep climb until the speed falls away to the stalling point.

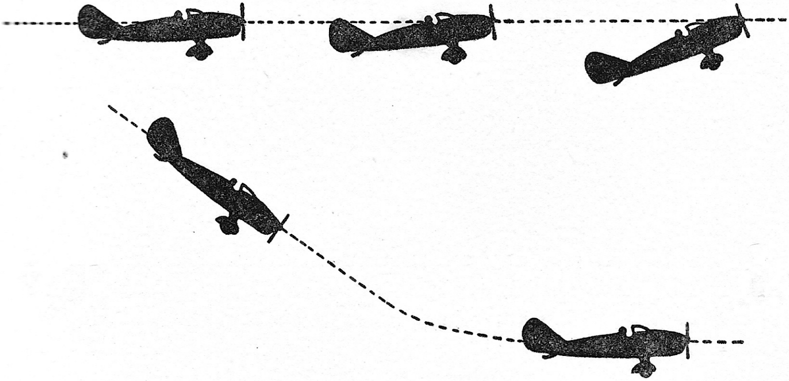

Fig. 19. Showing Stall and Recovery

Aeroplanes will react differently to stall, according to their types and the loads they carry. In earlier flying days, a machine tended to stall with alarming suddenness. Usually one wing dropped, and as the aileron control was ineffective it was impossible to hold the machine laterally level. A stall was usually accompanied by a spin or spinning nose dive.

The modern light aeroplane usually gives a reasonably long warning before it actually stalls, and the ailerons are so designed that they will remain effective at very low air speeds. If the plane is fitted with slots, this tends to delay the stall and also minimize its effects: instead of the nose dropping, the machine sinks on a more or less even keel and will recover from the stall much more quickly when the stick is eased forward.

Accidental Stalls. These are apt to occur when the pilot misjudges his speed and climbs or glides the machine too slowly. The stalling speed also rises when the machine is put into a turn. The steeper the turn, the faster it will be necessary to fly. Turning without sufficient speed or too steeply for a given speed is a frequent cause of accidental stalls. They may also occur through a mishandling of the controls when the aeroplane is flying not much above its stalling speed.

CLIMBING

The art of climbing will consist in maintaining the best speed of climb that is suited to a particular type of machine: the best climbing speed will always be that at which the machine gains the greatest height in the shortest time. This figure is determined by the makers before the machine is passed out.

We will suppose that our plane's climbing speed is 70 m.p.h. If we are cruising at a normal speed of 100 m.p.h. and wish to climb, we should ease the stick back until the needle on the air-speed indicator drops back to 70 m.p.h. If it drops to 50, we shall know that we are climbing too steeply and the stick must be eased forward a trifle until the needle comes back to 70. If it goes above 70, it means that the angle of climb is too flat and we must pull the stick back a little (Fig. 20). So long as we keep the needle on the 70 mark, we shall be climbing at the correct and consequently the best speed, though it will vary if we go high enough.

For a long climb the engine is kept running at its normal cruising revolutions. For a short climb the engine may be running at its fullest extent, that is, with the throttle lever pushed forward as far as it will go. This, however, should not be maintained for more than a thousand feet.

It is possible roughly to find a machine's best climbing speed without knowing it beforehand. The stick is pulled back, and the angle of climb is increased until the aeroplane gives little or no response to a lateral movement of the stick. This means that the ailerons have lost most of their effect and that we are approaching the stalling speed. The angle of climb is too steep. The stick is eased gently forward until it feels reasonably firm in the hand and the ailerons are effective, that is, the machine rocks a little when the stick is moved from side to side. When these conditions are established, the speed is noted on the air-speed indicator, and the reading given is approximately the best climbing speed.

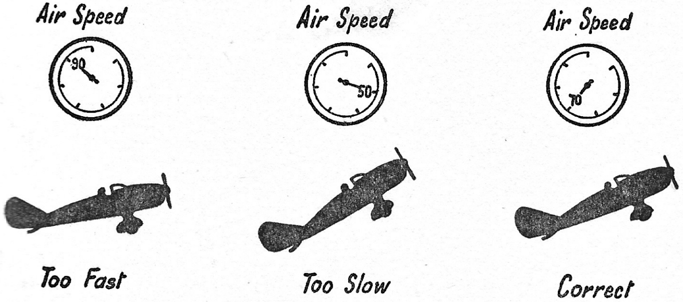

Fig. 20

GLIDING

Gliding is a method of losing height and covering as much ground as possible in the process. The engine is throttled back and the stick eased forward—here again it is a matter of speed. The figure will be roughly the same as that of the best climbing speed.

If this figure is not known, the pilot will put the nose of the machine downwards by easing the stick forward. If the lateral control begins to have little effect, it means that he is gliding too slowly. If, on the other hand, the controls become stiff, and this is accompanied by a high whistling note as the wind rushes by, then the speed is too fast and the stick must be eased back a little. When the plane is gliding with the lateral control firm and still effective, the speed registered on the air-speed indicator will be approximately the best gliding speed.

In rough weather, a pilot will glide rather faster than normally. If the air is rough, the machine is apt to be thrown about and the additional speed will afford the pilot better control to cope with these conditions.

When gliding near the ground, it is advisable to fly faster, so that there is a comfortable margin above the stalling speed.

TURNING

Effect of Rudder. It will be remembered that the rudder has the effect of turning the nose of the machine to the left and right when it is in level flight. We will now see what happens when we apply the rudder. A pressure with the right foot on the rudder bar will cause the nose to swing to the right, and if in an open plane, the pilot will feel a draught of wind striking him on the left cheek. This is because the machine is skidding sideways like a car that has tried to go too fast round a slippery corner. Obviously, the rudder by itself is not sufficient to make a proper turn. In fact, used by itself under some conditions, it is apt to produce a spin.

An aeroplane is made to turn by a combined use of the rudder and ailerons for a gentle turn. We shall see later that the elevator control may also play an important part.

Effect of Ailerons. We have seen that when the aileron control is applied, the machine banks. When turning, it is necessary to bank the plane in order to counteract the skidding effect which takes place when the rudder is applied by itself.

Those who have watched motor racing will know that the racing track is sometimes steeply banked on corners to prevent the cars skidding. On some roads, also, sharp corners are banked to counteract the force that tends to throw a vehicle outwards on a turn. In the same way, when a machine is banked, the reaction of its wing surfaces to this force (called centrifugal force) prevents it from skidding on a turn.

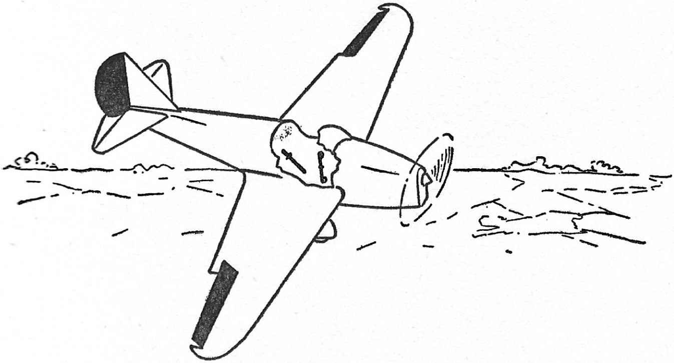

FIG. 21. RIGHT-HAND TURN, SHOWING POSITION OF RUDDER AND AILERONS

Note position of stick and rudder bar.

If we wish to make a gentle right-hand turn, we shall therefore apply right rudder and at the same time move the stick over to the right-hand side of the cockpit. The machine will bank and swing into a right-hand turn (Fig. 21).

Holding off Bank. If we continue turning, we shall find that the left (that is, the outside) wing tip tends to rise and the bank becomes steeper. This is because the outer wing is travelling faster than the inner wing and therefore receives more lift. It is pushed up higher, with the result that the machine banks over at a steeper angle.

It now becomes necessary to check the tendency to overbank by moving the stick over towards the other side of the cockpit. This procedure is known as holding off bank.

Coming out of a Turn. In order to come out of a turn, opposite bank and rudder are applied. When the machine is again on an even keel, the controls are centralized.

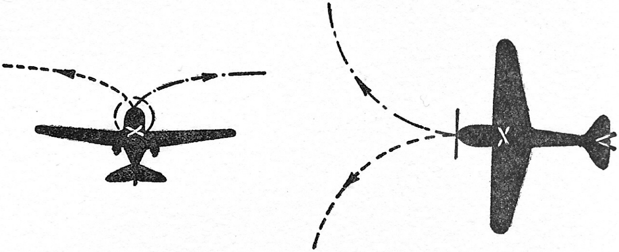

FIG. 22

Effect of Rudder in Steep Turns. In order to understand the effect of the controls when the machine is banked, we must get one thing clear. No matter what the attitude of the machine, the effect of any one control will always be the same. When thinking of the rudder, for instance, we must remember that it turns the nose of the plane as though towards the right or left wing tip (Fig. 22). If the machine is flying level, it means that the rudder will make the plane swing to the right or left. Imagine what will happen if the machine is so steeply banked that its left wing tip is pointing nearly towards the ground. If left rudder is applied, the machine will not swing to the left. It will, as we have said, swing as though towards its left wing tip, which is now pointing towards the ground.

The nose of the aeroplane will therefore swing towards the ground (Fig. 22).

If we applied right rudder under these conditions, the nose of the machine would swing towards its right wing tip, that is, upwards. It follows, therefore, that when a machine is very steeply banked, the rudder will make it travel in an upward or downward direction. It will, in fact, be doing what the elevator does in level flight.

Effect of Elevator. We know that the elevator will make the plane travel upwards or downwards in level flight. That is, it makes it travel as though towards its tail in a line over the top of the fuselage. In fact, if the stick is pulled far enough back when the machine is travelling at speed, the nose will rise and the aeroplane will turn right over in a loop, as though it were trying to catch its tail (Fig. 23).

Now, if the aeroplane is lying on its side very steeply banked, the nose will still turn towards the tail in a line over the fuselage when the stick is pulled back. It will be seen that it turns in a circle. In fact, it is behaving in very much the same way as it would if the rudder were applied in level flight.

Thus, when an aeroplane is banked to any degree, the effect of the controls will appear to change, though actually they have not done so. They are still moving the aeroplane in the same direction relative to itself.

Use of Elevator and Rudder. When turning, as in level flying, the nose of the machine must be kept on the horizon. Suppose we go into a right-hand turn by applying right rudder and right aileron. As the machine banks, the nose will tend to drop below the horizon. In order to bring it up we must use a little opposite rudder (that is, left) and elevator, according to the steepness of the turn. The rudder is being used to help in holding the nose up. It will be remembered that the elevator control has the effect of turning the aeroplane when it is steeply banked. Thus, in a steep turn, the elevator (and not the rudder) will be used to turn the nose of the machine in the direction desired by pulling back the stick.

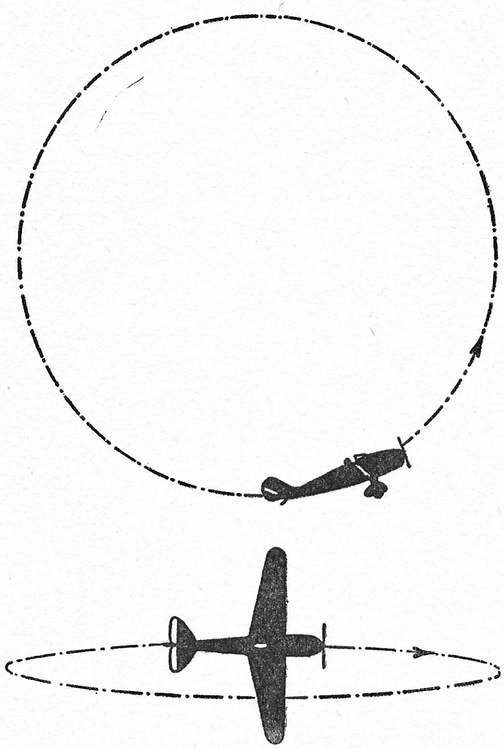

FIG. 23

The degree to which the rudder will be used to hold the nose on the horizon, and the elevator to turn the machine, will depend on the steepness of the turn. Generally speaking, the sharper the turn the steeper will be the bank. We have already noted that the stalling speed increases when the machine is banked, so in all except gentle turns the pilot will advance the throttle lever before commencing the turn.

Gliding Turns. Gliding turns (Fig. 24) will be employed when a pilot wishes to lose height and at the same time remain over the same area. When an aeroplane is coming in to land, it will usually be necessary for it to execute at least one or two gliding turns. The procedure is very much the same as for a level turn. Where increased speed is necessary, this is achieved by putting down the nose of the machine so that it glides faster. During a gliding turn the outer wing does not develop a tendency to rise during the turn. It is therefore unnecessary to hold off bank.

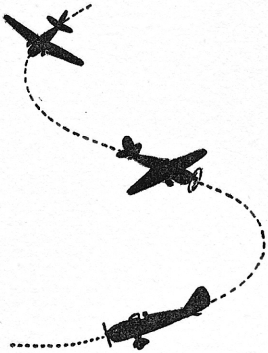

Fig. 24. Gliding Turns

Climbing Turns. These are used to avoid an obstacle when taking off or flying near the ground. Pilots are usually warned that they should not be used except in cases of necessity, for unless the pilot has considerable experience he is very liable to stall the machine. In any case, if the engine happens to falter during one of these turns, a stall is almost inevitable.

TAKING OFF

Wind Direction. Wherever the lie of the landing ground allows it, an aeroplane will take off into wind. If we remember what has been said about air speed, the reason for this will be clear. If an aeroplane were to take off with the wind behind it, it might at the best need a very long run before it could get into the air. There would also be some danger of its being blown over on to its nose.

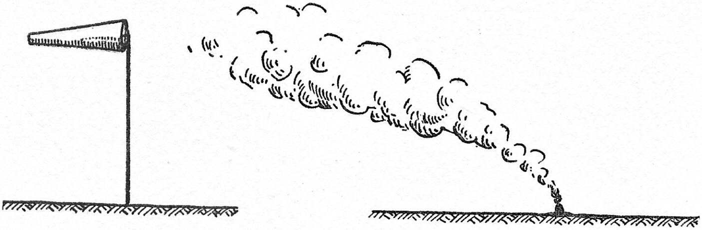

Fig. 25

Wind direction is usually indicated by what is known as a *wind sock* (Fig. 25). It will be seen that this is a sort of oblong bag (open at both ends) which is attached to the head of a mast. Alternatively, a column of smoke may show from which quarter the wind is blowing.

The aeroplane is taxied to the farthest end of the flying ground that will allow the longest run into wind. If this is done, the aeroplane will clear any obstacles at the farther end with a comfortable margin of height. It is also important in case of possible engine failure during the take-off.

The Take-off. When the machine is in position for starting, the tail trim is moved forward. The throttle is gently opened to its fullest extent and the stick is pushed right forward. This has the effect of making the tail rise. Before a machine can satisfactorily get into the air, the tail should be up so that the aeroplane is in flying position.

Steering. During the run across the ground, the aeroplane may tend to swing to the left or right, and this is checked by the use of the rudder. Some beginners find difficulty in this, as they are apt to forget that the speed is increasing all the while and the rudder is consequently becoming more sensitive. For this reason they tend to overcorrect a swing, with the result that they veer over in the other direction. In order to keep in a straight path, the machine should be steered by some point ahead on or near the boundary of the landing ground.

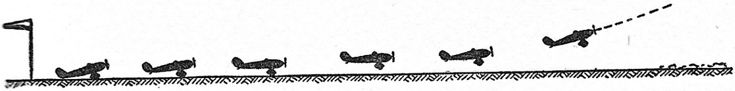

FIG. 25A. THE TAKE-OFF

Movements of Control Stick. As soon as the tail is up, the stick should be eased back towards the central or neutral position, when the aeroplane will usually leave the ground of its own accord (see Fig. 25A).

It is very important that the stick should be brought back from the forward position when the tail rises. If it is held forward too long, there is considerable risk of the aeroplane tipping forward on to its nose. If the stick is not held sufficiently far forward, the machine staggers off the ground tail down in a stalled position.

When an aeroplane leaves the ground, there is usually no sensation of lifting. It merely seems as if the bumpy movement over the ground had ceased. The forward motion becomes smooth, as though the machine were riding on air instead of wheels, which in fact is what has happened.

When the machine leaves the ground, the stick must still be kept central so that the machine can gain more forward speed before a climb is attempted. When sufficient speed has been obtained, the stick is eased gently back. After the first few hundred feet of climb, the engine is throttled back until it is turning over at normal cruising revolutions. This will usually be the case when the throttle lever is three-quarters of the way forward. When sufficient height has been gained, the stick is eased forward to the neutral position and the tail trim is moved back.

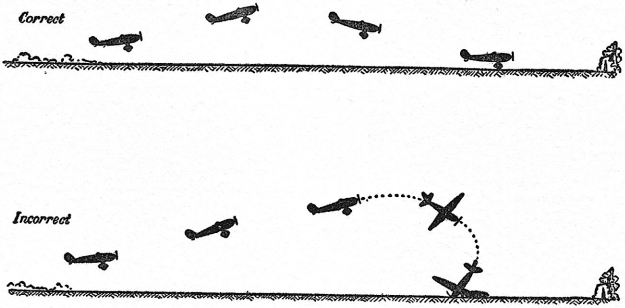

FIG. 26. ENGINE FAILURE ON TAKE-OFF SHOWING CORRECT AND INCORRECT PROCEDURE

Engine Failure on Take-off. This misfortune very rarely happens, but it is a state of emergency for which a pilot should be prepared. There is one golden rule which is impressed upon every pupil. If the engine cuts out on taking off, put the nose down and *go straight on.* It is generally possible to make a safe landing.

There may be trees or houses ahead on the boundary of the aerodrome, and the pilot on seeing these is sorely tempted to turn back towards the landing ground. Unless he has got a good margin of height in hand, the effects of turning back will *always* be disastrous (Fig. 26). When the engine stops, he will have comparatively little speed, and we have already seen that more speed will be necessary for the turn. Added to this, the wind will be behind him, so that his chances of bringing off a turn without stalling are very slight. Even if he does succeed, he will have to land with considerable speed, because the wind is behind him; and if he does not actually turn over on landing, he will usually collide with something at the far boundary of the landing area.

A number of pilots have come to grief through ignoring this rule when their engine failed on taking off. Many more can still congratulate themselves on getting out of trouble by putting the nose down and going straight on.

LANDING

This is usually the last essential manœuvre attempted by the pupil, and it is also the most difficult to master. Instructors are at pains to point out that the knack of landing will take rather longer to acquire than the other essentials of flying. For this reason pupils are warned not to be discouraged if they find that they are making slow progress. Landing is a matter of getting the eye, the brain, and the muscles to do their work properly together in unfamiliar circumstances. It needs practice, and usually comes to nearly everyone if they persevere long enough.

The Approach. This will consist in gliding down with the engine throttled back until one is ready to turn into the aerodrome and land. If the approach is misjudged, the pilot will find that one of two things is going to happen. Either he will get too low to come in safely clear of the aerodrome boundary, or he will come in too high and tend to overshoot the landing ground altogether.

In either case he has his engine to help him, and if he finds that he has misjudged, he should open up the engine, make a circuit of the aerodrome, and try again.

In accordance with the rules in existence at most aerodromes, the approach will usually be made so that the plane is gliding down, keeping the landing area on its left-hand side. In other words, if it makes a circuit or part of a circuit, it will be moving round the landing area anti-clockwise (Fig. 27).

Briefly, the approach will consist of a glide more or less parallel with one boundary of the aerodrome until the machine is at the correct height for turning in to make a landing. This glide preparatory to turning is made across the direction of the wind, so that when the turn is made towards the landing area, the aeroplane will be facing into wind (Fig. 27).

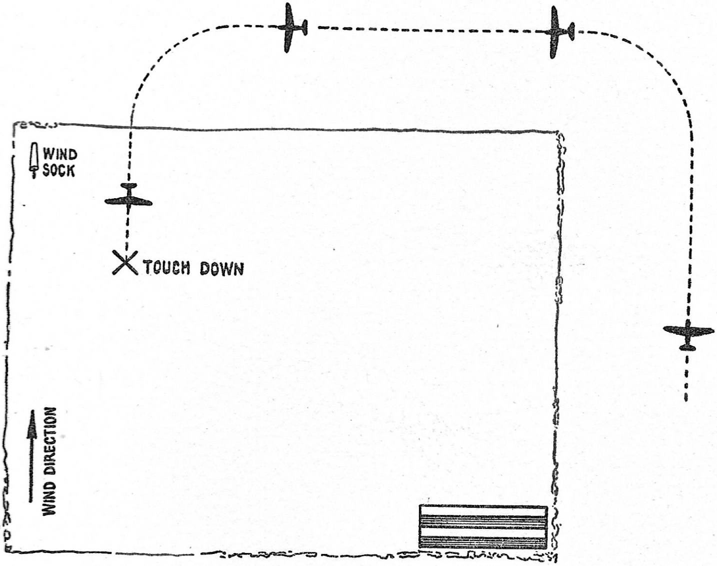

FIG. 27. SHOWING METHOD OF APPROACH

In common with the take-off, a landing must be made into wind. We have already discussed what is likely to happen if a pilot tries to land down wind.

The approach will usually be made along a line some

400 yds. distant from the boundary of the landing field. The plane will turn into wind when its height will allow it to glide comfortably down to a landing well within the first half of the landing area.

The Landing. At a point about 20 ft. from the ground the pilot makes a check in the angle of his descent. From now on the stick is eased slowly back. If the speed has been judged correctly, the plane should begin to sink gently down. When it is within a foot or so of the ground, the speed should have dropped almost to the stalling point. The stick is then pulled right back as far as it will go. The nose comes up and the wheels and tailskid touch down simultaneously (Fig. 28). This is called a three-point landing, and it is the kind of landing at which every pilot aims under normal conditions.

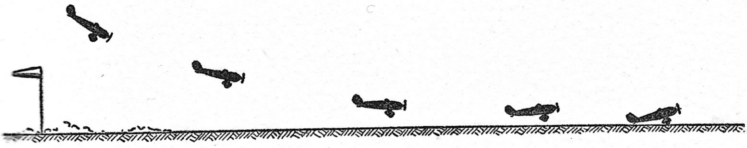

FIG. 28. SHOWING STAGES OF LANDING

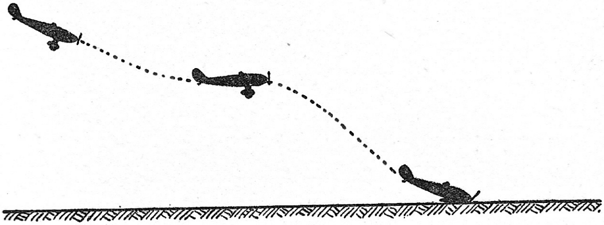

FIG. 29. POSSIBLE EFFECT OF FLATTENING OUT TOO HIGH

The timing of the final movement of the stick is very important. If it is made too soon, the aeroplane flattens out too high above the ground and flops heavily to earth (Fig. 29).

If it is done too late, it lands on its wheels and may bounce into the air. Many beginners make the mistake of trying to get the tail down when they have made a wheel landing. They pull the stick back, with the result that the machine shoots up or *balloons* into the air again (Fig. 30). From this position it stalls, usually several feet above the ground, and lands with a jar which may cause damage to the undercarriage. If a pilot makes a wheel landing, he must leave the controls alone, and the tail will come down of its own accord as the machine loses its forward speed.

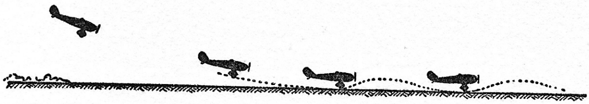

FIG. 30. EFFECT OF PULLING BACK STICK ON WHEEL LANDING

Engine Landing. We have seen that a good landing consists of a gliding approach followed by a turn into wind, and a landing in which the wheels and the tailskid touch the ground simultaneously. All this should be accomplished without the aid of the engine. Landing with bursts of engine is known as *rumbling in*, and this may become necessary on difficult or unfamiliar landing grounds or in rough weather. In normal conditions a pupil is not encouraged to rumble. If he has to use his engine to cover a mistake, he is advised to keep it on, make another circuit of the aerodrome, and try again.

Side-slipping. This is a method of losing height without increasing the forward speed of the machine. It may become necessary when landing in confined spaces or be employed when a pilot finds that he is too high above the landing area.

To bring about a side-slip, right bank is applied. The machine will then begin to slip downwards, and, to prevent the nose dropping left rudder is applied. We saw how the rudder was used to help in holding the nose up when a machine was banked. It may be necessary to use the elevator as well. The nose should not be held too high, otherwise the flying speed may fall away. The speed registered by the air-speed indicator should be the same as that in a normal glide. The machine slips downwards, but with very little forward speed, at the same time remaining under control (Fig. 31).

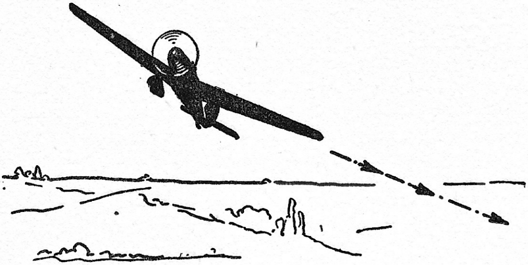

FIG. 31. SIDE SLIP

To come out of a side-slip, a little opposite rudder is applied and the stick is eased forward. The machine will settle in a gliding turn, which is straightened out in the normal manner.

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